Performance of the MPD detector for the study of strongly-intensive multiplicity and transverse momentum fluctuations in heavy-ion collisions

Evgeny Andronov, Igor Altsybeev, Daria Prokhorova

Saint Petersburg State University

Introduction

The MPD experiment would be a unique environment to study phase diagram of strongly interacting matter in a high baryonic density domain. One of the signatures of phase transitions in this region would be non-monotonic behaviour of fluctuations-related observables as a function of collision energy and/or system size [1]. In this contribution we perform analysis of joint fluctuations of multiplicity and transverse momentum in NICA energy range based on Monte Carlo simulations.

Observables:

Strongly intensive - do not depend on volume and volume fluctuations in the model of independent sources [2]:

$$\Delta[P_T, N] = \frac{\langle N\rangle\omega[P_T] - \langle P_T\rangle\omega[N]}{\langle N\rangle\omega[[p_T]]}$$

$$\Sigma[P_T, N] = \frac{\langle N\rangle\omega[P_T] + \langle P_T\rangle\omega[N] - 2cov(P_T, N)}{\langle N\rangle\omega[[p_T]]}$$

N-multiplicity
P_T-total transverse momentum
[[..]] - moments over tracks <..> or [..]- moments over events
ω-scaled variance

- $\Delta = \Sigma = 1$ for Poisson multiplicity distribution
- $\Delta = \Sigma = 1$ in model of independent particles
- $\Delta = \Sigma = 0$ in case of absence of fluctuations

Analysis

Dataset:

- SMASH model [3], hadronic transport code
- Bi+Bi at $\sqrt{s_{NN}} = 9.46$ GeV
- 4 millions of events
- Reconstructed in MpdRoot (MpdMiniDst format)
- MPD Request 6 production

Centrality selection:

Procedures of centrality determination based on information in MPD FHCals and track multiplicity are still under development. Therefore, simplified approach of event selection in classes of impact parameter was used

Event selection:

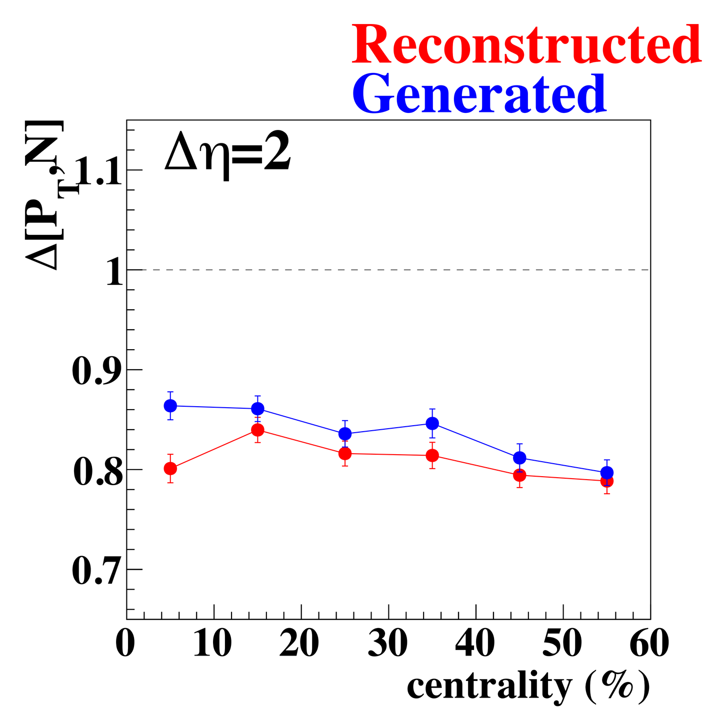
☑ |vtxZ|<20cm ☑ min number of tracks > 2

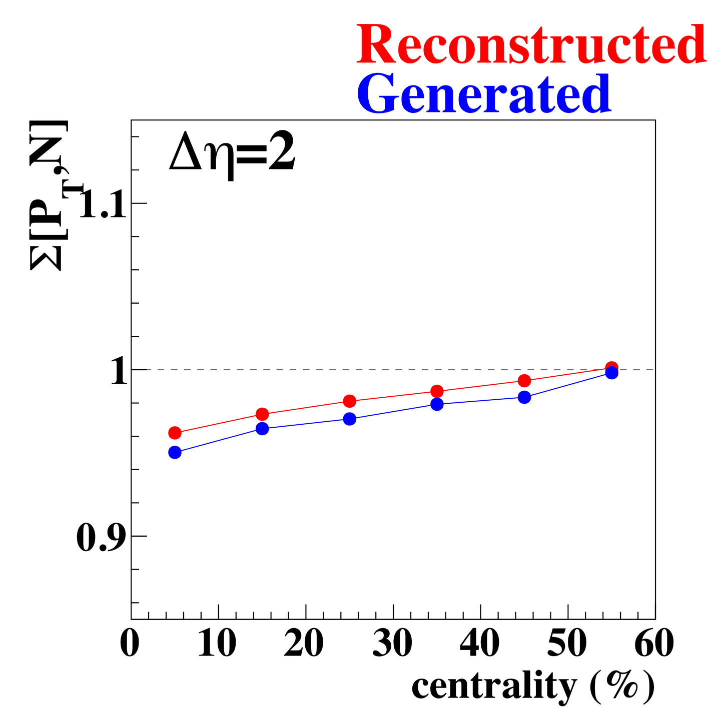
Track selection:

☑ minimum 30 hits in TPCs ☑ $\chi^2/N_{hits} < 5$ ☑ $|\eta| < 1$ ☑ $0.15 < p_T < 2\ GeV/c$ ☑ $DCA < 2.2\ cm$

Results: centrality dependence

Results were obtained for generated data and for reconstructed data in centrality classes of 10% width in $|\eta| < 1$ interval. They are presented as a function of center of centrality class (in percentiles). Statistical uncertainties were obtained using the subsample method.

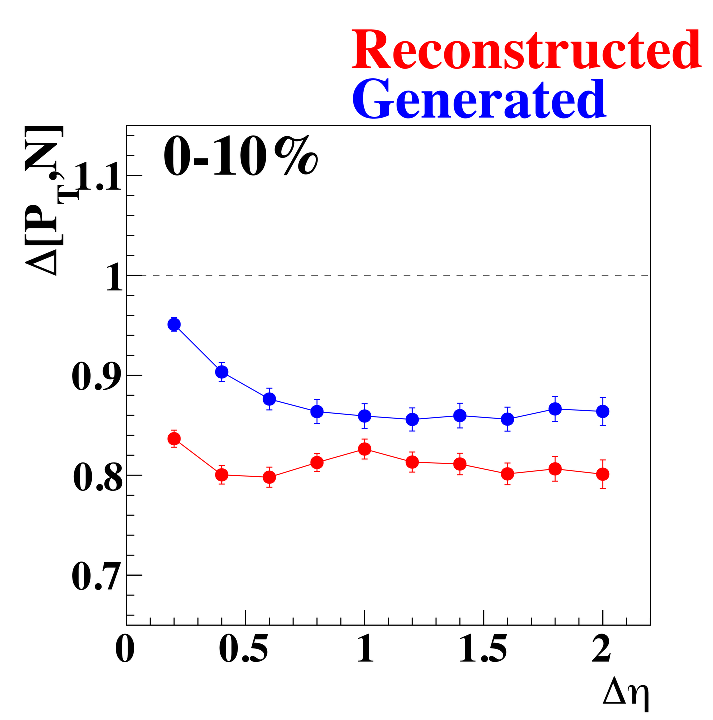


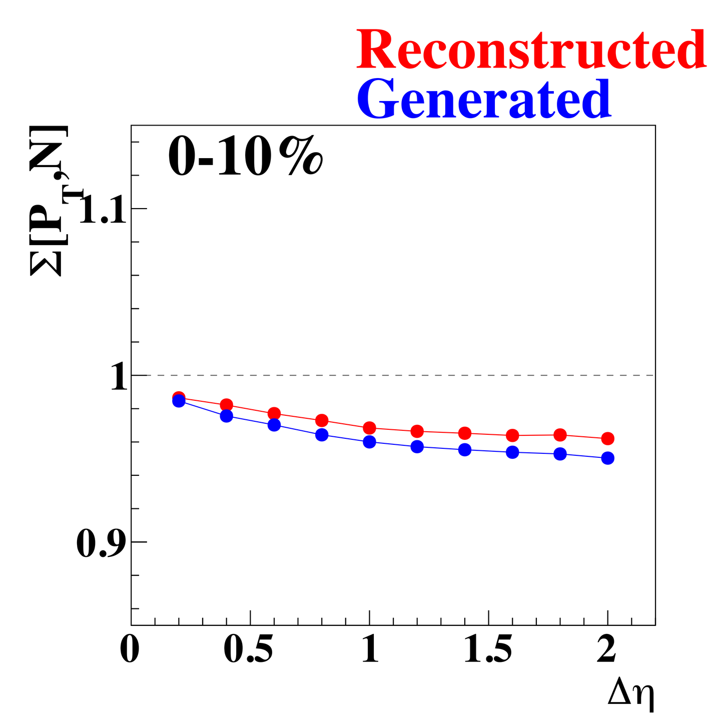


- Clear centrality dependence is present in SMASH
- Effect of detector inefficiency is moderate

Results: rapidity dependence

Rapidity dependence of fluctuating observables probes different regions of the phase diagram [4]. We performed analysis in intervals of pseudorapidity starting from $|\eta| < 0.1$ up to $|\eta| < 1$

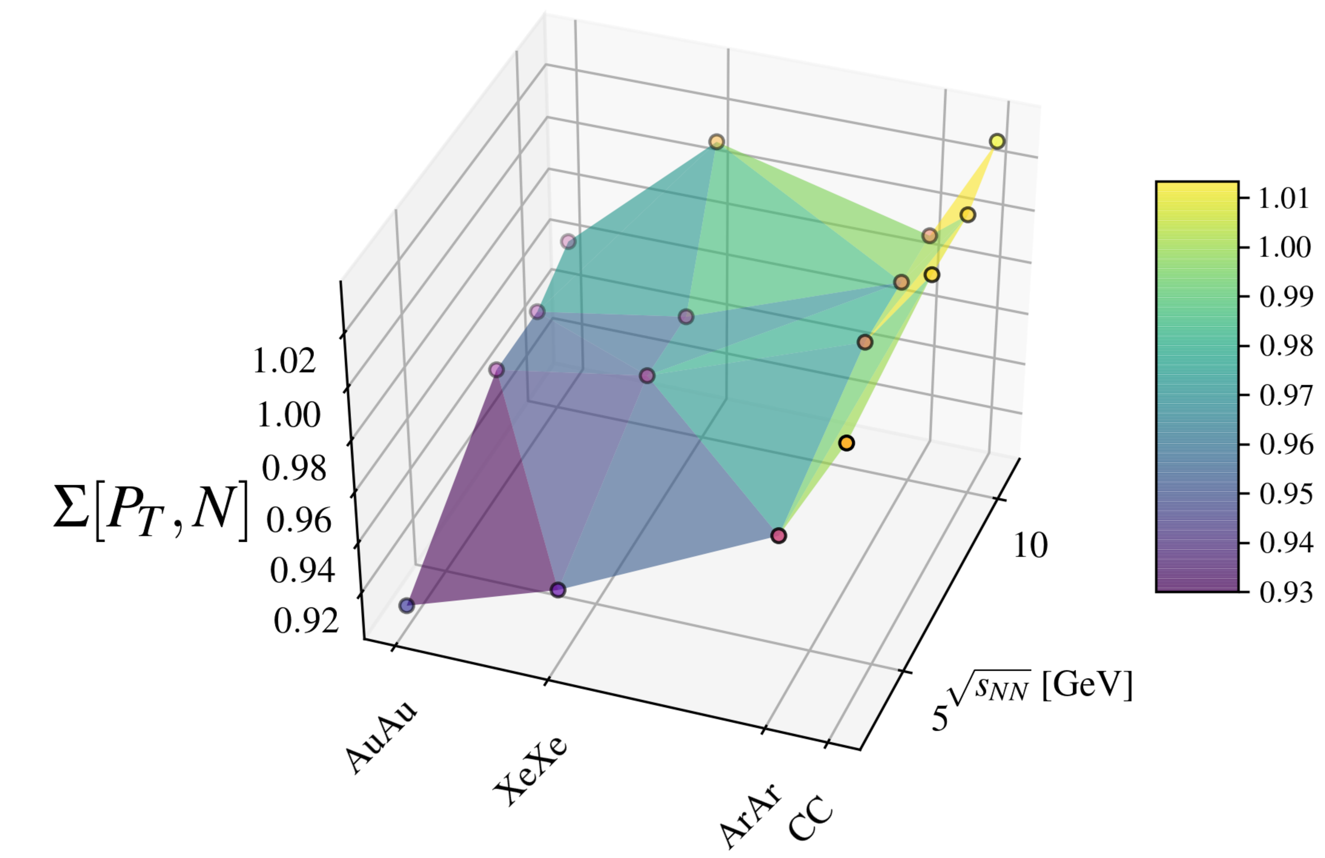




- Monotonic behaviour with the increase of rapidity interval
- Effect of detector inefficiency becomes stronger for smaller intervals in case of $\Delta[P_T, N]$

2d scan of phase diagram

- SMASH model, C+C, Ar+Ar, Xe+Xe, Au+Au at $\sqrt{s_{NN}} = 4; 7; 9; 11$ GeV
- 20 millions of min bias events
- 0-10% <b> for AA (recalculated to <Npart> using Glissando3 [5])
- MPD Request 8 production (only generated level)



SMASH does not include description of critical phenomena. Nevertheless, obtained non-critical estimation have a non-trivial behaviour.

Summary and Plans

Joint fluctuations of multiplicity and transverse momenta are calculated within the SMASH model under realistic conditions of the MPD experiment for Bi+Bi collisions - most probable reaction for the start of NICA. Results of the additional analysis for the possible beam energy scan program are presented.

In the future, this analysis will be extended with a more realistic centrality selection based on the information from the forward detectors (MPD FHCal) and track multiplicity. Also, it is planned to make a comparison with predictions of events generators that take into account hydrodynamic stage, and to study moments of the event-mean transverse momentum distribution [6].

References

1. M. Bluhm et al., Nucl.Phys. A 1003, 122016 (2020)
2. M. Gorenstein, M. Gazdzicki, Phys.Rev. C 84, 014904 (2011)
3. J. Weil et al., Phys.Rev. C 94, 054905 (2016)
4. E. Andronov, Nucl.Phys. A 982, 835 (2019)
5. P. Bozek et al., Comput. Phys.Commun. 245, 106850 (2019)
6. G. Giacalone et al., arXiv:2004.09799 [nucl-th]

This work is supported by RFBR under grant 18-02-40097

e.v.andronov@spbu.ru